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(71) Applicant: KIMBERLY-CLARK WORLDWIDE, INC. [US/US]; 401 North Lake Street, Neenah, WI 54956 (US).

(72) Inventors: COHEN, Bernard; 381 Lakeshore Drive, Duluth, GA 30136 (US). TAYLOR, Julie, Rowan; 1604 Holly Lake Circle, Snellville, GA 30278 (US).

(74) Agents: HARPS, Joseph, P. et al.; Kimberly-Clark Worldwide, Inc., 401 North Lake Street, Neenah, WI 54956 (US).

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(54) Title: ANTIMICROBIAL MEDICAL DEVICES AND METHODS OF PRODUCTION AND USE

(57) Abstract

Medical implants or devices such as catheters resistant to microbial growth prepared by subjecting a medical device to electret treatment, preferably by electrostatic charging. The medical device or implant is composed of a dielectric material, or coated with a dielectric substance. The dielectric material or coating substance on the surface of the device or implant retains a positive or negative charge. The device or implant is charged either prior to or after packaging. The device or implant is packaged in a container or wrap that maintains sterility. The device or implant is sterilized either during formation, prior to charging, or after charging. Sterilization may be conducted either before or after packaging depending on the type of packaging utilized. The charged device or implant catheter resists microbial growth and is particularly useful for inhibiting bacterial infections when inserted into a patient, thereby providing a device that can remain in contact with, inserted in or implanted in the patient for a longer period of time with reduced risk of microbial infection.

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ANTIMICROBIAL MEDICAL DEVICES AND METHODS OF PRODUCTION AND USE

Field of the Invention

The present method relates to the field of medical devices and more specifically relates to medical devices that resist microbial growth *in situ*.

Background of the Invention

Infection is a frequent complication of many surgical, therapeutic, or diagnostic procedures. Although extreme precautions are taken to ensure the sterility of medical devices and implants prior to and during contact with a human or animal patient, contamination can occur. For example, medical devices placed on or near a patient, such as gloves, condoms, monitors, and other medical equipment may introduce infection through an incision, wound or burn. Furthermore, medical devices or implants placed within a patient for an extended period of time may provide a depot of bacteria, viruses, or fungi that, if allowed to grow unheeded, could causes serious illness or even death.

The catheter has become the medical device of choice throughout the medical field for the removal or delivery of fluids, including pharmaceutical drugs, to patients. Catheters have been used over the past fifty years for intravenous, urological, cardiac care, wound drainage, and hydrocephalus treatment with great success. However, serious infections associated with catheter use, such as septicemia and urinary tract infections, or cystitis, have become prevalent, particularly in patients who have had the devices left *in situ* for long periods of time. The treatment of catheter induced infection can be costly and difficult, especially in a patient that is immunocompromised or recovering from an extensive surgical procedure. To avoid the onset of infection, medical personnel recommend that a catheter be replaced every

forty-eight hours or less. Unfortunately, this safety practice may be impractical in certain situations, such as in the use of central venous catheters.

The mechanisms of catheter induced infection are not well known. Catheters are routinely packaged and sterilized under conditions that maintain sterility until use. It is therefore believed that contamination occurs during removal from the packaging, during insertion into the body, or after the catheter has been inserted. The use of sterile techniques, such as handling the catheter with sterile gloves and cleansing the insertion site to prevent contamination of the catheter tip during insertion, have reduced infection to some degree. However, it is believed that, even if the catheter is substantially free of contamination upon insertion, organisms gather at the insertion site and migrate through the opening caused by the presence of the catheter and replicate along the length of the catheter causing internal infection. The use of topical antibiotics at the catheter insertion site have caused a slight, but statistically insignificant, decrease in infection rates.

Numerous attempts have been made to reduce *in situ* infection by treating medical devices such as catheters, prior to insertion, with an antimicrobial substance. For example, U.S. Patent No. 4,592,920 to Murtfeldt and U.S. Patent No. 5,320,908 to Sodervall *et al.* discuss the use of a thin layer of a metal, such as silver, on a catheter to reduce the incidence of infection. U.S Patent No. 4,259,103 to Malek *et al.* discloses a method of reducing infection by coating a catheter with an organic amine. U.S. Patent No. 4,563,485 to Fox, Jr. *et al.* teaches the incorporation of nalidixic acid derivatives into medical implants and devices to reduce infection. U.S. Patent No. 4,581,028 to Fox, Jr. *et al.* teaches the incorporation of metal salts of sulfonamides into medical implants and devices to reduce infection. U.S. Patent No. 4,612,337 to Fox, Jr. *et al.* teaches soaking a polymeric material with an antimicrobial agent, such as sodium sulfadiazine, and a metal salt of

the antimicrobial agent to reduce infection. U.S. Patent No. 5,019,096 to Fox, Jr. *et al.* teaches the incorporation of a silver salt and chlorhexidine into medical implants and devices to reduce infection. However medical personnel are generally concerned with the instability and leaching of such antibacterial agents and caution against the use of coated catheters. (T. S. J. Elliott, "Intravascular-device infections", *J. Med. Microbiol.* 27:161-167 (1988))

Canadian Patent No. 1,112,533 and U.S. Patent Reissue No. Re. 31,873 teach a multilumen catheter device designed to reduce infection. However, many physician recommend avoidance of multilumen catheters because evidence has shown that multilumen catheters promote infection by providing an additional site for microorganism entry. (Hampton and Sherertz, "Vascular-Access Infections in Hospitalized Patients", *Surgical Clinics of North America* 68:57-71 (1988); Corona *et al.*, "Infections Related to Central Venous Catheters", *Mayo Clin. Proc.* 65:979-986 (1990))

Therefore, there is an on-going need for medical implants or devices, such as catheters, that resist microbial growth and minimize the onset of infection.

Summary of the Invention

Medical devices or implants resistant to microbial growth and methods of production and use are described. In accordance with the method, a medical device or implant composed of a dielectric material, or coated with a dielectric substance, is subjected to electret treatment. The preferred electret treatment is electrostatic charging. The dielectric material or coating substance on the surface of the medical device or implant thereby attains a positive or negative charge. The device or implant is treated either prior to or after packaging. The device is packaged in a container or wrap that maintains sterility. The device or implant is sterilized either during formation, prior to treatment, or after

treatment. Sterilization may be conducted either before or after packaging depending on the type of packaging utilized.

When allowed to come in contact with a patient or inserted or implanted into a patient, the electret treated medical device or implant resists microbial growth *in situ*, thereby providing a device that can remain in contact with, implanted, or inserted for a longer period of time with a higher degree of safety than currently available devices, particularly catheters.

The present invention provides a simple, rapid, and inexpensive method for producing medical devices and implants, such as catheters, that resist microbial growth *in situ*.

The present invention also provides antimicrobial devices that can remain inserted in a patient for greater than forty-eight hours without promoting infection at the insertion site or in the tissues or fluids in contact with the device.

The present invention also provides a method for inhibiting infection in catheterized patients by utilizing a catheter that has been subjected to electret treatment.

Detailed Description of the Disclosed Embodiments

Medical devices or implants resistant to microbial growth and methods of production and use are provided. In accordance with the method, a medical device or implant composed of a dielectric material, or coated with a dielectric substance, is subjected to electret treatment. The electret treated medical device or implant is resistant to microbial growth, particularly microbial growth *in situ*.

Medical devices embodying the present invention include all types of medical devices that contact patients or are important in health care, such as, but not limited to, table tops, hospital beds, monitors, and various specific

medical devices, as long as the devices are capable of being subjected to electret treatment. A medical device that cannot be conveniently treated, due to its size, shape or material composition, may include a removable surface that is more easily treated. Medical devices are those for use both externally and internally. Suitable medical devices and implants include, for example, urinary catheters, both internal and external; intravenous catheters; and cardiac catheters, including those useful for balloon angioplasty; contraceptives such as condoms; medical gloves, such as surgical and examination gloves; wound dressings; drainage tubes; orthopedic, penile and other implants; wound clips; sutures; hernia patches; arterial grafts; respiratory therapy devices, such as ventilator or trachea tubes; and heart valves. The medical devices or implants or the surfaces of medical devices or implants, sometimes generally together referred to herein as "surfaces", can be made of a variety of natural or synthetic materials such as plastics and polymers, and include Dacron®, rubber, latex, silicone, polyurethane, polyvinyl chloride, Teflon®, polypropylene, polyethylene, polyolefins, poly(lactic acid), and polyglycolic acid.

The preferred electret treatment method is electrostatic charging. The dielectric material or coating substance on the surface of the device or implant thereby attains a positive or negative charge. The surface need not retain the charge throughout the use of the device or implant, but should be charged when the device or implant comes in contact with or is implanted or inserted into the patient, referred to herein as *in situ*. The device or implant is charged either prior to or after packaging. The device or implant is packaged in a container or wrap that maintains sterility. The device or implant is sterilized either during formation, prior to treatment, or after treatment. Sterilization may be conducted either before or after packaging depending on the type of packaging utilized.

The term "medical device" as used herein includes medical implants. The medical device most particularly suited for electret treatment in accordance with the preferred method of production and use described herein is the catheter.

When placed in contact with a patient or implanted or inserted into a patient, the electret treated medical device or implant resists microbial growth *in situ*, thereby providing a device that can remain in contact with, implanted or inserted for a longer period of time with a higher degree of safety than currently available devices. An electret treated catheter for the delivery of a fluid or gas is particularly useful because the time interval between replacements can be extended.

Microorganisms

The surfaces of medical devices or implants treated in accordance with the present method resist the growth of a wide variety of microorganisms including, but not limited to, bacteria, viruses, yeasts and fungi. In particular, the treated devices or implants are useful in situations where it is desirable to inhibit the *in situ* growth of bacteria including, but not limited to, *E. coli*, staphylococci (most particularly coagulase-negative staphylococci and *S. aureus*) streptococci, diphtheroids, *Propionibacterium*, *Enterobacter*, *Serratia*, *Enterococcus*, *Proteus*, *Yersinia*, and other gram-negative bacilli including *Klebsiella* and *Pseudomonas*. In addition, the treated devices or implants are useful for inhibiting the *in situ* growth of yeasts such as *Candida*.

Although not wishing to be bound by the following, it is believed that the charged surface of the devices or implants provides a hostile environment to microorganisms that inhibits or retards microbial reproduction.

Catheter Design and Composition

The medical devices described herein are particularly useful for reducing the incidence of infection in a patient in whom a catheter must be inserted.

Such catheters are most particularly useful for reducing infection in a patient in whom a catheter must remain in place for forty-eight hours or more. By inhibiting the growth or microorganisms or reducing infection, the electret-treated catheters described herein are particularly useful for inhibiting or reducing bacterial infections such as septicemia, bacteriuria, urinary tract infections and cystitis when inserted into a patient requiring catheterization.

All types of catheter designs may be electret treated to achieve a reduction in microbial growth on the surface of the catheter as described herein. Such catheters include, but are not limited to, the following general categories of catheters: cardiac, urethral, vascular, renal, neurological, respiratory, gynecological and wound drainage catheters. Such catheters specifically further include, but are not limited to, urological, intravenous, and intracardiac catheters; and catheters used for balloon angioplasty, middle ear drainage, hemorrhage control, hydrocephalus treatment, irrigation, ventilation, removal of prostatic obstruction, dilation, calibration, and sample collection from areas of the body such as the lung or renal pelvis.

The preferred catheter is composed of a natural or synthetic material capable of retaining a charge after subjection to an electric charge, commonly referred to by those skilled in the art as a dielectric material. Alternatively, the catheter is coated with a dielectric material. The term "dielectric" is defined herein as a material, such as a polymer, which is an electrical insulator or in which an electric field can be sustained with a minimum dissipation of power. A solid material is a dielectric if its valence band is full and is separated from the conduction band by at least 3 eV. This definition is adopted from the McGRAW-HILL ENCYCLOPEDIA OF SCIENCE & TECHNOLOGY, 7th Edition, Copyright 1992. Suitable dielectric materials include, but are not limited to, a variety of plastics and polymers such as silicone, Teflon™, Dacron™, latex, rubber, polyester, nylon, polyurethane, polyvinyl chloride, polypropylene,

polyethylene, poly(lactic acid), polyglycolic acid, and polyolefins in general, and derivatives thereof.

Charging Techniques

Any type of charging methodology and equipment capable of charging a dielectric material is suitable for treating medical devices or implants to inhibit microbial growth in accordance with the present method. Electrostatic charging is preferred. The resulting charge on the surface of the dielectric material may be either positive or negative. Methods of subjecting a material to charging, for example electrostatic charging, are well known by those skilled in the art. These methods include, for example, thermal, liquid-contact, electron beam and corona discharge methods.

Briefly, corona discharge is achieved by the application of sufficient direct current (DC) voltage to an electric field initiating structure (EFIS) in the proximity of an electric field receiving structure (EFRS). The voltage should be sufficiently high such that ions are generated at the EFIS and flow from the EFIS to the EFRS. Both the EFIS and the EFRS are preferably formed from conductive materials. Suitable conductive materials include conductive metals such as copper, tungsten, stainless steel and aluminum.

A preferred charging technique is described in U.S. Patent No. 5,401,446, assigned to the University of Tennessee, which is incorporated by reference herein. This technique involves subjecting a material to a pair of electrical fields having opposite polarities. Each electrical field forms a corona discharge. A more preferred charging technique is the electret technique described in U.S. Patent No. 5,370,830 to Cohen and Jameson, which is incorporated by reference herein. Briefly, the electret technique of Cohen and Jameson involves passing a dielectric material through a corona discharge treatment assembly consisting of a positive and negative electrode, one above and one below the dielectric material. Each electrode is powered by a power

supply. The material is passed through the corona discharge at a convenient speed. The corona discharge treatment assembly applies positive volts to one surface of the material and negative volts to the other surface of the material.

When the medical device or implant is electret treated after packaging, it is important to use an electret technique in which the spacing between the electrodes is sufficient and the voltage is adjusted to prevent arcing due to the inherent flammability of many packaging materials and the possibility of creating holes in the packaging materials. The preferred spacing between electrodes for a conventional catheter is approximately between 1 and 2 inches (or 2.5 cm and 5 cm). For other medical devices or implants, the spacing between the material being subjected to electret treatment and the electrodes must be adjusted to accommodate the size and shape of the item.

Packaging

As mentioned above, the medical device or implant may be packaged either before or after being subjected to electret treatment or charging and may be sterilized either before or after electret treatment. Preferably, the medical device or implant is packaged prior to treatment. The size of the packaging and composition of the packaging material may influence the type of charging apparatus and method that can be successfully utilized.

Materials useful for packaging sterile or sterilizable medical devices or implants, such as catheters, are well known to those skilled in the art. Suitable packaging materials include, for example, polymeric materials such as polyethylene and spun fibers of polyethylene (such as Tyvec™). Preferably, the device or implant is packaged with a layer of opaque packaging material affixed by an adhesive or heat seal to a layer of transparent material so that the device or implant can be identified both visually and by a printed description. Optionally, the device or implant has an additional internal wrapping,

preferably composed of a transparent polymer material similar to that described above.

For use in the present method, the packaging material should be sterilizable and have the ability to maintain sterility during the storage, transport and handling of the medical device or implant. In addition, if the device or implant is packaged prior to being subjected to charging, the packaging material must allow the charge or charges to pass through to the device or implant and must be capable of withstanding the charging technique without deterioration.

Sterilization

Methods for sterilizing catheters and other medical devices and implants are well known to those skilled in the art and may be utilized in the present method. Suitable sterilization methods include, but are not limited to, steam sterilization, plasma sterilization, ethylene oxide sterilization, gamma radiation sterilization, and ozone sterilization. In accordance with the present method as mentioned above, the device or implant may be subjected to charging followed by sterilization or subjected to sterilization followed by charging. In addition, the device or implant may be sterilized before or after packaging, provided that, in the latter case, the sterilization method is capable of penetrating the packaging material. Alternatively, the device or implant may be formed and packaged under sterile conditions.

The antimicrobial medical devices or implants and methods of production and use described above will be further understood with reference to the following non-limiting examples.

Example 1

Effect of Electret Treatment on *E. coli* Growth on Catheters: Qualitative Observations

Four Argyle™ Teflon™-coated latex Foley™ catheters in their packaging were electret treated to impart a charge of approximately 1,000 volts. One additional catheter provided the untreated control. Two of the treated catheters were charged with approximately 1,000 negative volts and two with approximately 1,000 positive volts.

The catheters were cut into approximately 5 cm sections and incubated for 24 hours in a solution of protein containing *E. coli* (final concentration 10^9/ml). These sections were washed three times in a solution of protein. The sections were then rolled on Tripticase™ Soy Agar plates. (Carr Scarborough Microbiological Labs. Inc., Atlanta, GA) The plates were incubated for a sufficient amount of time to allow normal bacterial growth. The development of *E. coli* growth on the plates was observed.

The qualitative observations demonstrated less growth in the negatively charged catheters than in the untreated catheter and the two positively charged catheters.

Example 2

Effect of Electret Treatment on *E. coli* Growth on Catheters: Quantitative Analysis

Catheters in sterile packaging were electret treated and subsequently incubated with bacteria. Electret treated and non-treated control catheter samples were analyzed for the ability to support bacterial growth as generally described by Sherertz *et al.*, *J. Clin. Microbiol.* 28:76-82 (1990), Muller *et al.*, *Infection and Immunity* 59:3323-3326 (1991), and Lawrence *et al.*, J. Bacteriology 173:6558-6567 (1991).

<u>Experimental Procedure</u>:

Twenty milliliters of Soybean Casein Digest Broth (Becton Dickinson, Cockeyville, MD) were inoculated with 650 CFU (colony forming units) of *E. coli* (ATCC #25922) for each sample tested. Five catheters (Dover All Silicon Foley™ #605189 catheters, Sherwood Medical, St. Louis, MO) were used as untreated controls, and five catheters were electret treated while in their sterile packaging. Electret treatment was performed by placing the catheter packages between electrodes with the Tyvec™ spun fiber of polyethylene (opaque) layer facing the negatively charged electrode. The spacing between the electrodes was approximately 1 inch. Charging was conducted with a charge on the negative electrode of -12 Kv to -10 Kv and a charge of +12 Kv to +10 Kv on the positive electrode. The operating temperature was approximately 68°F to 72°F and the relative humidity from approximately 30% to 60%. The through-put speed was from approximately 10 to 20 feet per minute. This electret process caused each catheter to be negatively charged (approximately 1500 volts). Data from previous experiments had demonstrated that similar catheters held this charge for more than six months.

Three 1 inch samples were cut from each of the ten catheters, providing a total of 30 samples. The samples were cut from the central portion and not the balloon ends of each catheter. The samples were immersed in 20 ml of the Soybean Casein Digest Broth that had been inoculated with 650 CFU of *E. coli* (ATCC #25922) and the samples were incubated with *E. coli* at 37°C for 24 hours. The catheter pieces were handled asceptically in order to prevent contamination.

The samples were washed three times and the wash fluid analyzed as follows. Samples were placed in a first vessel containing 100 ml of "Fluid D" (an aqueous solution containing a peptic digest of animal tissue, and polysorbate 80, as defined in THE UNITED STATES PHARMACOPEIA (USP23) -

THE NATIONAL FORMULARY (NF18) 1995, page 1687: United States Pharmacopeial Convention, Inc., Rockville, MD) and shaken on a mechanical shaker for 10 minutes. (Wash 1) Samples were removed from the first vessel and placed in a second vessel containing 100 ml of "Fluid D" and shaken on a mechanical shaker for 10 minutes. (Wash 2) Samples were removed from the second vessel and placed in a third vessel containing 100 ml of "Fluid D" and shaken on a mechanical shaker for 10 minutes. (Wash 3) The samples were removed from the third bottle, and the recoverable CFU per sample in the fluid from each of the vessels was quantitated.

The samples were then placed in a fourth vessel containing 100 ml of "Fluid D" and sonicated for 5 minutes at 60 kHz.

Serial plate dilutions from 10^{-1} to 10^{-5} were made from the wash fluids of each vessel. Plates were incubated for 48 hours at 37°C. The recoverable CFU per sample was then calculated.

The Wilcoxon 2-Sample Test, T-Test, and Kruskal-Wallis Test (Chi-Square Approximation) was used to test statistical differences between the electret-treated and the non-treated control catheters.

<u>Results</u>

The results are shown below in Tables 1-4 below. As shown in Table 4, the final wash fluid of the treated samples (samples 1-5) grew only approximately one third as much bacteria as the untreated control samples (samples 1A-5A), based on mean distribution and approximately one quarter as much bacteria based on medium distribution, demonstrating that electret treatment results in a statistically significant inhibition of bacterial growth, as shown in Table 5. (In Table 5, both the treated and untreated groups were not normally distributed. The median is better than the mean for measuring central tendency of non-normal data.)

The electret-treated catheters had significantly less bacterial growth than the untreated control catheters. The probability of significance was 0.0042, 0.0077, and 0.0039 by the Wilcoxon 2-Sample Test, T-Test, and Chi-Square Approximation, respectively.

Table 1
Total Aerobic Bioburden as CFUs per Catheter Sample in Wash Fluid from First Vessel (Wash 1)

Sample Number	Piece #1	Piece #2	Piece #3
1	7.2×10^9	7.6×10^8	2.2×10^8
2	4.2×10^9	1.0×10^9	1.4×10^9
3	4.9×10^9	6.1×10^8	3.4×10^8
4	7.2×10^8	1.8×10^9	2.9×10^8
5	3.7×10^9	6.8×10^9	1.4×10^9
1A	1.2×10^9	1.8×10^9	1.2×10^9
2A	3.7×10^8	7.4×10^8	3.9×10^8
3A	5.9×10^9	1.4×10^9	3.6×10^8
4A	2.7×10^9	2.5×10^8	5.7×10^8
5A	4.1×10^9	2.8×10^8	4.2×10^8

Table 2
Total Aerobic Bioburden as CFUs per Catheter Sample in Wash Fluid from Second Vessel (Wash 2)

Sample Number	Piece #1	Piece #2	Piece #3
1	2.2×10^6	1.0×10^7	3.3×10^6
2	7.7×10^6	9.4×10^6	2.9×10^6
3	9.1×10^6	1.4×10^7	1.3×10^7
4	9.8×10^6	5.4×10^6	1.2×10^7
5	1.4×10^7	1.1×10^7	9.3×10^6
1A	1.6×10^7	9.3×10^6	1.0×10^7
2A	1.9×10^7	7.7×10^6	1.1×10^7
3A	1.3×10^7	4.0×10^6	1.5×10^7
4A	1.9×10^7	1.1×10^7	6.9×10^6
5A	9.5×10^6	1.6×10^6	1.1×10^7

Table 3
Total Aerobic Bioburden as CFUs per Catheter Sample in Wash Fluid from Third Vessel (Wash 3)

Sample Number	Piece #1	Piece #2	Piece #3
1	5.3×10^4	7.4×10^4	9.9×10^5
2	5.0×10^5	3.3×10^5	5.4×10^4
3	4.3×10^5	3.4×10^5	3.0×10^5
4	6.9×10^5	1.7×10^5	9.7×10^5
5	6.8×10^5	9.1×10^5	2.0×10^5
1A	6.5×10^5	6.7×10^5	6.0×10^5
2A	6.6×10^5	1.3×10^6	7.8×10^5
3A	1.2×10^6	9.5×10^5	2.6×10^5
4A	1.0×10^6	1.4×10^6	6.6×10^5
5A	8.7×10^5	9.4×10^5	2.1×10^5

Table 4
Total Aerobic Bioburden as CFUs per Catheter Sample in Wash Fluid from Final Vessel Sonication

Sample Number	Piece #1	Piece #2	Piece #3
1	3.7×10^5	1.8×10^6	1.2×10^6
2	4.7×10^5	1.7×10^5	7.7×10^4
3	9.9×10^4	2.5×10^5	5.4×10^5
4	4.8×10^5	5.8×10^4	2.0×10^5
5	2.5×10^5	6.6×10^5	1.4×10^5
1A	2.5×10^6	8.1×10^5	7.6×10^5
2A	9.4×10^5	1.3×10^6	5.1×10^5
3A	8.7×10^6	6.2×10^5	5.1×10^5
4A	6.3×10^5	1.1×10^6	1.6×10^6
5A	3.5×10^4	9.9×10^5	9.1×10^5

Table 5
Experimental Results
Based on Statistical Analysis of Data

Condition	Normal Distribution	CFU Mean	CFU Median
untreated	No	1,461,000	910,000
treated	No	450,933	250,000

Modifications and variations of the present medical devices and implants and methods of production and use thereof will be obvious to those skilled in the art from the foregoing detailed description. Such modifications and variations are intended to come within the scope of the appended claims.

Claims

We claim:

1. ~~An~~ antimicrobial medical device or implant comprising an electret treated dielectric material, wherein the growth of microorganisms on the medical device or implant is inhibited.

2. The device or implant of Claim 1 comprising a catheter.

3. The device or implant of Claim 1 wherein the dielectric material is electrostatically charged.

4. The device or implant of Claim 1 wherein the dielectric material is sterilized.

5. The device or implant of Claim 1 wherein the dielectric material is packaged.

6. The device or implant of Claim 1 wherein the growth of microorganisms on the surface of the medical device is inhibited *in situ*.

7. The device or implant of Claim 1 further comprising a non-dielectric material coated with the dielectric material.

8. A method of producing an antimicrobial medical device or implant comprising subjecting the device or implant to electret treatment.

9. The method of Claim 8 wherein the medical device is a catheter.

10. The method of Claim 8 wherein the electret treatment is electrostatic charging.

11. The method of Claim 8 further comprising sterilizing the device or implant.

12. The method of Claim 8 further comprising packaging the device or implant.

13. The method of Claim 8 wherein the growth of microorganisms on the surface of the device or implant is inhibited.

14. A method for inhibiting a bacterial infection in a patient to be catheterized comprising inserting an electret treated catheter into the patient.

15 The method of Claim 14 wherein the bacterial infection is selected from the group consisting of septicemia, bacteriuria, urinary tract infections, and cystitis.

16 The method of Claim 14 wherein the catheter has been electrostatically charged.

17. The method of Claim 14 wherein the growth of microorganisms on the catheter surface is inhibited while the catheter remains inserted in the patient.

18. The method of Claim 14 wherein the catheter remains in the patient for 48 hours or greater.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/14186

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61L29/00 //A61L27/00,A61L31/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 346 058 A (T.S.J. ELLIOTT ET AL) 13 December 1989	1-3,6, 8-10,13, 15,17,18
Y	see the whole document	4,5,7, 11,12, 14,16
Y	US 4 142 521 A (J.J. KONIKOFF) 6 March 1979 see column 2, line 65 - column 4, line 21 see column 5, line 25 - line 40 see column 7, line 46 - line 53; claims	4,5,7, 11,12, 14,16
Y	WO 85 01507 A (ALFA-LAVAL AGRI INTERNATIONAL) 11 April 1985 see page 2, line 5 - line 17 see page 3, line 31 - line 38; claims	1-16

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 1997	17/12/1997
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2	Authorized officer

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	PATENT ABSTRACTS OF JAPAN vol. 11, no. 229 (C-436), 25 July 1987 & JP 62 042715 A (AKAMOTO TAKAHIRO), 24 February 1987, see abstract	1,6-8,13
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A	US 4 072 146 A (R.M. HOWES) 7 February 1978 cited in the application	
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